Hot Operating Temperature Technology

High Temperature Diamond Electronics for Actuators and Sensors

Completed Technology Project (2017 - 2020)

Project Introduction

This project will develop diamond electronics for actuator and sensor applications at high temperatures (>500°C) which are appropriate for the surface of Venus and other solar system missions that explore high temperature environments. Specifically, we propose to develop, test and simulate diamond p-i-n diodes and pnp bipolar transistors for actuator control and low noise pnp transistor circuits for sensor amplification. Diamond is a wide band gap semiconductor with outstanding semiconductor properties that have long been recognized for high power, high frequency, and low noise applications. Diamond has the highest known thermal conductivity, which enables high power operation, and the high electron and hole mobilities of diamond are unusual compared to all other wide band gap semiconductors and support both high power and high frequency applications. The wide bandgap and bipolar operation enables low noise amplification with bipolar transistors. Moreover, these properties and the stability of diamond contribute to its potential as a high temperature semiconductor capable of operating at temperatures well above 500°C. Compared to other wide bandgap semiconductors, diamond has demonstrated bipolar operation, which is difficult to achieve with GaN based devices, and its lack of crystal polytypes provides improved stability at high temperature compared to SiC based devices. This project proposes devices that take advantage of the high stability of diamond p-n junctions based on doping with boron and phosphorus. Diffusion of these substitutional dopants is essentially negligible at temperatures less than 800°C, and the diamond crystal structure is certainly stable at even higher temperatures. The objectives of this project are to demonstrate pin diodes and pnp BJTs for operation up to 500°C, and to demonstrate low noise amplification with optimized BJT transistor based circuits. To achieve these objectives the team will 1) fabricate 50V, 1A pin diamond diodes and test at temperatures up to 500°C, 2) fabricate 50V, 1A pnp bipolar junction transistors and test up to 500°C, 3) design, fabricate and test pnp based low noise amplifier circuits, 4) simulate device performance and project operation at higher temperatures, 5) identify specific mission objectives that would be impacted by diamond diodes, transistors or low noise amplifiers, and 6) develop a technology transfer strategy that includes cost projections for fully packaged and tested devices.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

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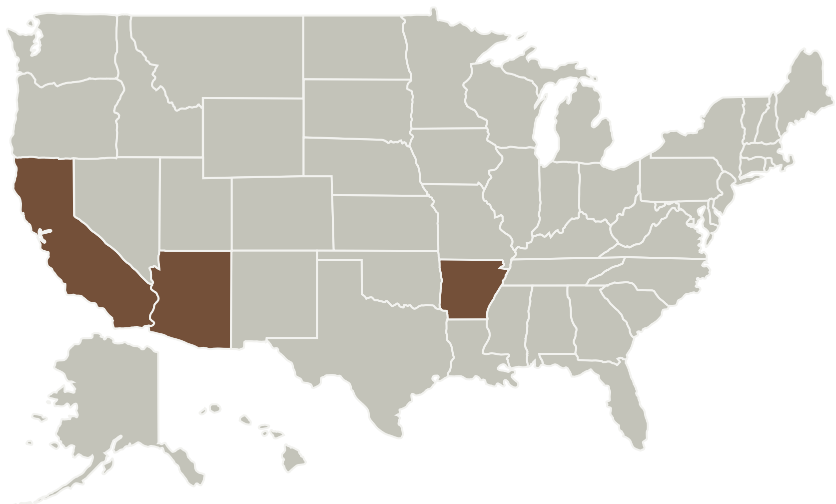
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Arizona State University-Tempe(ASU)	Supporting Organization	Academia Alaska Native and Native Hawaiian Serving Institutions (ANNH)	Tempe, Arizona

Primary U.S. Work Locations	
Arizona	Arkansas
California	

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Quang-viet Nguyen

Principal Investigator:

Robert Nemanich

Co-Investigators:

James Lyons
Brianna S Eller
Stephen M Goodnick
Srabanti Chowdhury
Franz A Koeck
Sarah Gates

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - └ TX08.1 Remote Sensing Instruments/Sensors
    - └ TX08.1.1 Detectors and Focal Planes

Target Destination

Others Inside the Solar System